HUC 11070207 – Shoal Creek, Pogue Creek, and Joyce Creek
Water body IDs: 3320, 3321, 3322, 3323
303(d) Listing: Fecal Coliform

Total Maximum Daily Load
Implementation Strategies

for the

Shoal Creek, Pogue Creek, and Joyce Creek
Newton and Barry Counties

Pollutant: Bacteria

09/12/2022

Prepared by: Water Protection Program, Watershed Protection Section

WATER BODY SUMMARY

Location:
Newton and Barry counties


State map showing location of watershed

8-digit Hydrologic Unit Code (HUC):[1]
11070207

12-digit HUC Subwatersheds
110702070706 - Zerbert Branch-Shoal Creek
110702070701 – Joyce Creek
110702070702 – Headwaters Shoal Creek

Water Body Identifications (WBIDs), Hydrologic Class, Length, and Extent:[2]
3230 – Shoal Creek – P – 15.7 miles – from Section 15, Township 25N, Range 29W to S12, T23N, R29W
3231 – Shoal Creek – C – 7.4 miles – from S12, T23N, R29W to S4, T22N, R28W
3232 – Pogue Creek – C – 2.5 miles – from mouth to S32, T24N, R24W
3233 – Joyce Creek – C – 5.0 miles – from mouth to S16, T24N, R28W

Designated Uses:[3]
Irrigation
Livestock and wildlife protection
Human health protection
Warm water habitat (aquatic life)
Cool water habitat (WBID 3230 only)
Whole body contact recreation category A (WBID 3230 only)
Whole body contact recreation category B (WBIDs 3231, 3232, and 3233)
Secondary contact recreation

Impaired Use:
Whole body contact recreation category A (WBID 3230)
Whole body contact recreation category B (WBID 3231, 3232, and 3233)

Pollutant addressed by TMDL:
Fecal coliform (fecal indicator bacteria)

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[1] Watersheds are delineated by the U.S. Geological Survey using a nationwide system based on surface hydrologic features. This system divides the country into 2,270 8-digit hydrologic units (USGS 2019). A hydrologic unit is a drainage area delineated to nest in a multilevel, hierarchical drainage system. A hydrologic unit code is the numerical identifier of a specific hydrologic unit consisting of a 2-digit sequence for each specific level within the delineation hierarchy (FGDC 2003).

[2] For definitions of hydrologic classes see 10 CSR 20-7.031(1)(D). Stream length and extent from 10 CSR 20-7.031 Table H.

[3] For designated uses see 10 CSR 20-7.031(1)(F) and 10 CSR 20-7.031 Table H. Presumed uses are assigned per 10 CSR 20-7.031(2)(A) and (B) and are reflected in the Missouri Use Designation Dataset described at 10 CSR 20-7.031(2)(E).

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1. Introduction

A total maximum daily load (TMDL) report for Shoal Creek, Pogue Creek, and Joyce Creek addresses elevated bacteria concentrations that resulted in these water bodies placement on Missouri's 303(d) List of Impaired Waters in 1998, 2004, and 2006 respectively. A TMDL for Shoal Creek (WBID 3231) was approved in 2003. In 2007, the department revised the TMDL to include an additional segment in Shoal Creek (WBID 3231), Pogue Creek, and Joyce Creek. The TMDLs approved in 2007 for the impaired water bodies represent the fecal coliform loading capacity for each stream, which is the maximum amount of that pollutant each water body can assimilate and still attain and maintain water quality standards. Watershed characteristics and information about potential sources can be found in the TMDL report, which is available on the Missouri Department of Natural Resources' website at dnr.mo.gov/water/what-were-doing/water-planning/quality-standards-impaired-waters-total-maximum-daily-loads/tmdls.

This implementation strategies document is a companion to the TMDL report and suggests actions that will reduce pollutant loading in order to meet the water quality goals established in the TMDL document. The goals of the TMDLs are to attain and maintain designated uses of whole body contact recreation category A (WBID 3230 only) and category B (WBIDs 3231, 3232, and 3233) in the water bodies. Since the time of the approval of the TMDLs in 2007, criteria for another indicator bacterium *Escherichia coli* (*E. coli*) have replaced fecal coliform on the Water Quality Standards (10 CSR 20.7031). This document provides updated loading targets based on applicable *E. coli* criteria. These target loads do not replace the TMDLs that were approved in 2007, but provide targets that are consistent with current water quality standards regulations. This information is provided for informational purposes only to guide watershed management planning activities and the implementation of best management practices.

This document neither prescribes nor prohibits any specific practices or technologies for reducing pollutant loading in the impaired water bodies and is not intended to serve as the sole means of remediation and restoration. However, the Department recognizes that technical guidance and support are critical to achieving the goals of any TMDL. Therefore, while the TMDL calculates the maximum pollutant loading that the impaired water bodies can assimilate and still attain and maintain water quality standards, this strategies document provides additional information to assist in meeting the TMDL loading goals including: pollutant reduction strategies, example calculations of pollutant reductions, potential participants in the watershed, and funding sources. Because the TMDL addresses pollutant loading from all potential sources in the watershed, this strategies document provides guidance for meeting the loading targets assigned to both point and nonpoint sources.[4]

[4] Point and nonpoint sources are defined and discussed in Section 1.7 of the TMDL report for Shoal, Joyce, and Pogue Creek.

Point source pollutant loading controls are implemented primarily through the Missouri State Operating Permit program.[5] Effluent limits are established in facility permits based on the assumptions and requirements of the wasteload allocations and other recommendations in the TMDL documents. Cost-share loans are available from the State Revolving Fund and are administered through the Department's Financial Assistance Center to help finance facility upgrades that may be necessary to meet more stringent effluent limits.

Watershed management practices that reduce nonpoint source pollutant loading are conducted voluntarily by interested stakeholders and landowners within the watersheds. In accordance with Section 319 of the federal Clean Water Act, the U.S. Environmental Protection Agency (EPA) provides funding for nonpoint source pollutant load reduction practices. Section 319 nonpoint source subgrants are administered by the Department through Missouri's Section 319 program to assist organizations with watershed planning or implementation of activities described in an approved nine element watershed-based plan (or alternative plan under certain specific conditions). The Nine Key Elements of a Watershed Management Plan are provided in Appendix A. More information on Missouri's Section 319 subgrant program is available at: dnr.mo.gov/water/what-were-doing/nonpoint-source-pollution-section-319. Potential government support and sources of funding are provided in Section 11 of this document.

2. Watershed Characteristics

Shoal Creek contains three different classified segments: WBID 3220, 3221, and 3232. Shoal Creek flows for 66 miles in Missouri before it enters Kansas about 5 miles southwest of Joplin where it joins the Spring River. The segments addressed in this TMDL are the two upper segments 3220 and 3221. The WBID 3231 is the Class C portion of Shoal Creek, immediately upstream of WBID 3230. The WBID 3230 segment ends at the confluence of Shoal Creek and Capps Creek. In this document the two upper segments will be called Upper Shoal Creek. The Upper Shoal Creek watershed drains an area of approximately 87 square miles in Barry and Newton counties in southwest Missouri (Figure 1). The Shoal Creek watershed is located within the Spring River subbasin which is cataloged by the U.S. Geological Survey (USGS) as the 8-digit hydrologic unit code (HUC) 11070207. In a 1992 USGS report, Shoal Creek was described as a true Ozarkian stream with rolling Ozark hills, picturesque mill dams, bedrock riffles, gently eddying pools and long shaded reaches. Pogue Creek and Joyce Creek are tributaries to Shoal Creek, located in its upper watershed.

Land cover types present in Shoal, Pogue, and Joyce Creek watersheds are summarized in Table 1. Figure 2 depicts the distribution of the land cover types throughout the watershed. Agricultural areas

[5] The Missouri State Operating system is Missouri's program for administering the federal National Pollutant Discharge Elimination System (NPDES) program. The NPDES program requires all point sources that discharge pollutants to waters of the United States to obtain a permit. Issued and proposed operating permits are available online at dnr.mo.gov/water/business-industry-other-entities/permits-certification-engineering-fees

(cropland, hay/pasture) cover approximately 75 percent of the watershed.

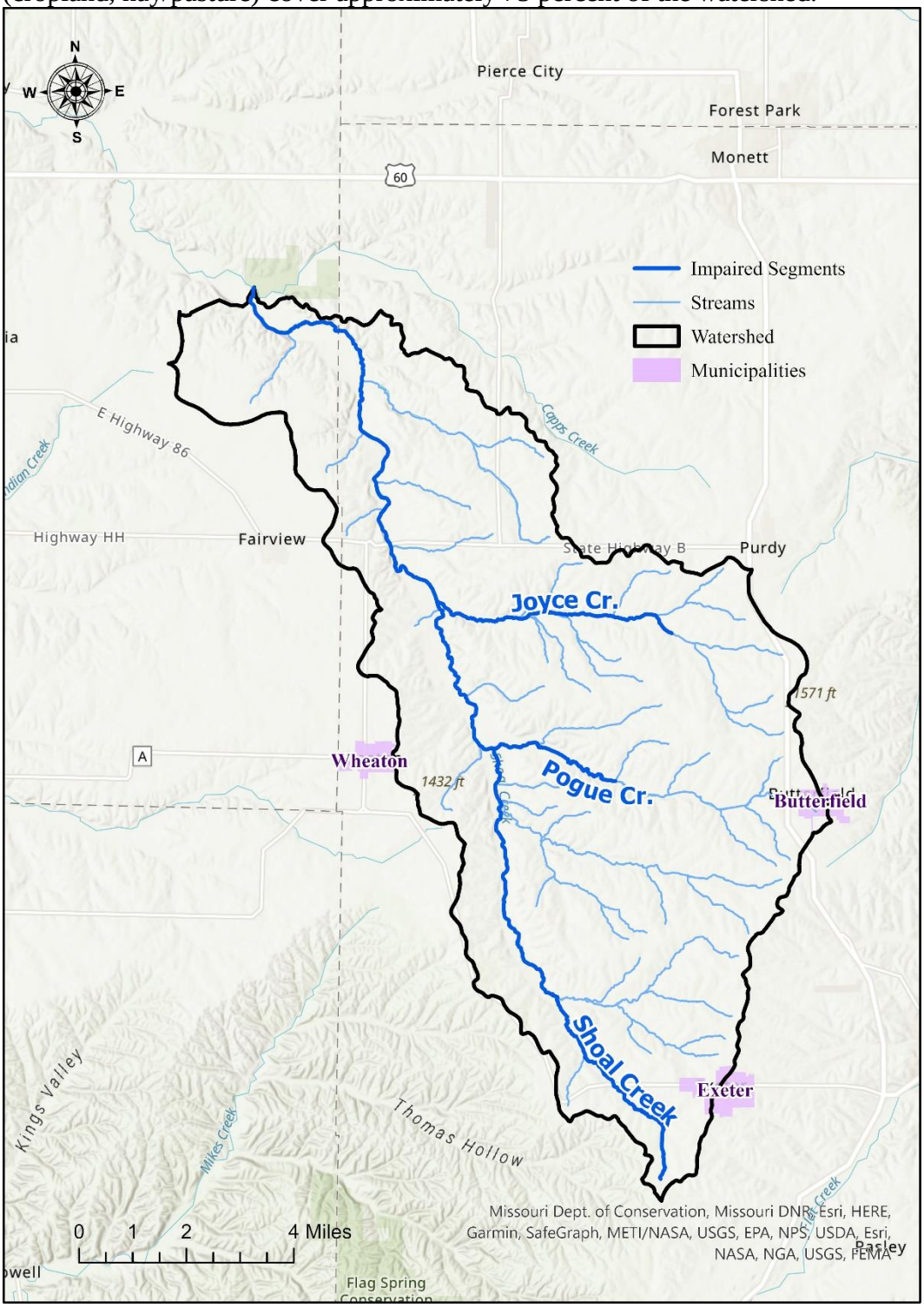

Figure 1. Location of the Upper Shoal Creek Watershed

Table 1. Land Cover in the Upper Shoal Creek Watershed

Land Cover Type	Area Square Miles	Percent
Developed, High Intensity	0.17	0.19%
Developed, Medium Intensity	0.75	0.86%
Developed, Low Intensity	1.35	1.56%
Developed, Open Space	3.39	3.90%
Barren Land	0.05	0.05%
Cultivated Crops	2.05	2.35%
Forest	13.16	15.14%
Hay/Pasture	65.16	74.99%
Open Water	0.04	0.04%
Shrub and Herbaceous	0.76	0.87%
Wetlands	0.02	0.03%
Totals	86.89	100.00%

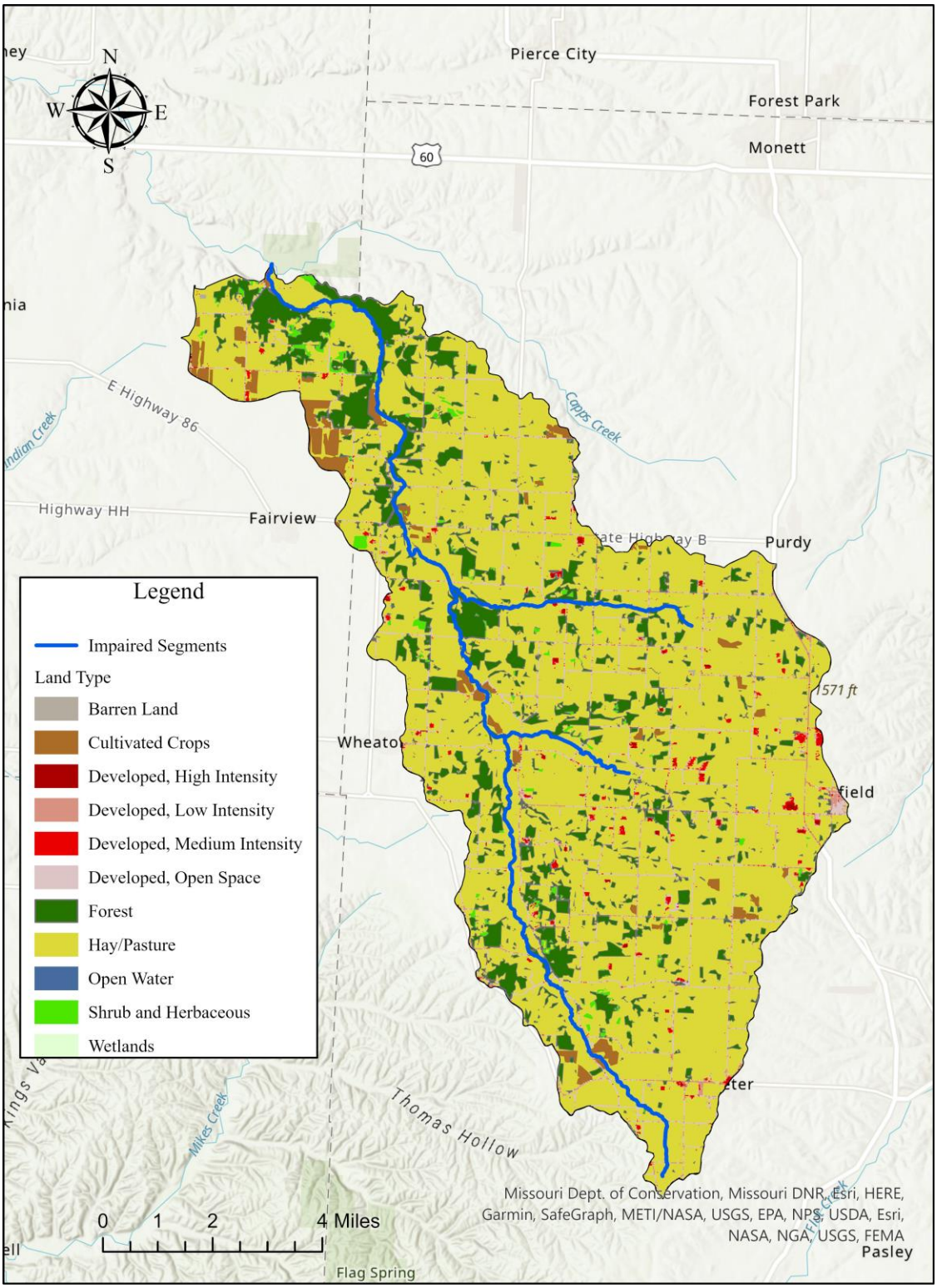

Figure 2. Land Cover in the Upper Shoal Creek Watershed

3. Water Quality Impairments

Water quality criteria represent a level of water quality that supports and protects particular designated uses. The whole body contact recreation category A designated use is impaired due to high *E. coli* bacteria concentrations in Shoal Creek and the whole body contact recreation category B designated use is impaired due to high *E. coli* bacteria concentrations in Pogue Creek and Joyce Creek. The TMDL approved in 2007 addressed the bacteria impairment based on the fecal coliform criteria of 200 colonies (col)/100 milligrams per liter (mL). Since the approvals of the Shoal Creek TMDLs, the criteria for bacteria is based on *E. coli*. *E. coli* are bacteria found in the intestines of humans and warm-blooded animals and are used as indicators of potential fecal contamination and risk of pathogen-induced illness to humans. The criteria for whole body contact recreation category A is 126 colony forming units per 100 mL of water in the most recent three years

Whole body contact recreation includes activities that involve direct human contact with waters of the state to the point of complete body submergence (10 CFR 20-7.031(1)(C)2.A.). During such activities, such as swimming, accidental ingestion of the water may occur and there is direct contact to sensitive body organs, such as the eyes, ears, and nose. Whole body contact category A applies to waters that have been established by the property owner as public swimming areas welcoming access by the public for swimming purposes and waters with documented existing whole body contact recreation uses by the public (10 CSR 20-7.031(1)(C)2.A.(I)). Whole body contact category B applies to waters designated for whole body contact recreation not contained within category A (10 CSR 20-7.031(1)(C)2.A.(II)). Secondary contact recreation, which includes activities such as boating, fishing, and wading, are activities that may result in contact with the water that is either incidental or accidental and the probability of ingesting appreciable quantities of water is minimal (10 CSR 20-7.031(1)(C)2.B.). The secondary contact recreation uses are not impaired in Shoal, Pogue, and Joyce Creeks.

The criteria for whole body contact recreation category A is a geometric mean of 126 colony forming units per 100 mL of water for samples collected during the recreational season (April-October) in the most recent three years having available data with five or more samples.[6] The whole body contact recreation category A is impaired for Shoal Creek because in years with five or more samples *E. coli* concentrations exceeded the geometric mean of 126 colony forming units (cfu)/100 mL in Shoal Creek in 2016-2009 (Table 2 and Figure 3). The criteria for whole body contact recreation category B is a geometric means of 206 cfu per 100 mL. This use is impaired for Pogue Creek and Joyce Creek as shown in Table 2 and Figure 3.

[6] Listing Methodology documents are available online at dnr.mo.gov/water/what-were-doing/water-planning/quality-standards-impaired-waters-total-maximum-daily-loads/tmdls

Table 2. Summary of Recreational Season *E. coli* Data for the Impaired Streams

Water Body	Recreational Season	Number of Samples	Max (cfu/100 mL)	Min	Geometric Mean (cfu/100 mL)
Shoal Creek (WBID 3230)	2016	4	4,839	307	1,635
	2015	5	4,839	185	1,292
	2013	6	770	33	314
	2010	20	1733	98	520
	2009	30	4,840	57	714
Shoal Creek (WBID 3231)	2016	5	189	17	189
	2015	8	2,420	8	199
	1999	11	58,000	13	767
Pogue Creek	2016	13	4,839	205	1,002
	2015	21	2,419	108	841
	2001	5	4,900	1,940	3,177
	1999	10	9,800	20	343
Joyce Creek	2016	8	4,839	66	686
	2015	11	2,419	84	444
	2001	3	1,120	195	418
	1999	10	46,000	140	672

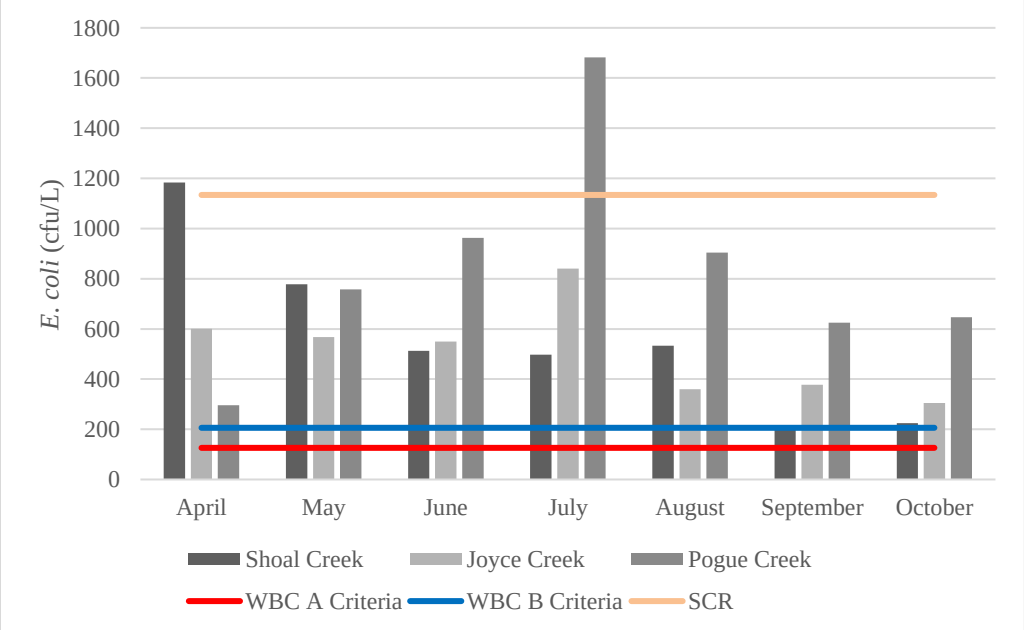

Figure 3. *E. coli* Geometric Means by Month (Includes years with <5 samples)

4. Causes and Sources of Pollutant Loads

4.1 Agricultural Areas

Croplands, pasturelands, and low-density animal feeding operations are potential sources of bacteria in surface waters. Bacteria are transported in runoff from areas fertilized with animal manure and where livestock are present. Runoff can result from precipitation or excessive irrigation. Section 640.760 Revised Statutes of Missouri (RSMo) establishes setback distances for surface application of liquefied manure from a confined animal feeding operation (CAFO) by a third party.[7] Pursuant to Section 640.760 RSMo, the Department may enforce stricter setbacks. Soil and Water Conservation Districts provide funding and guidance for the development of nutrient management plans for private lands. Areas where nutrient management plans guide manure application and where best management practices are used to reduce soil erosion contribute less bacteria to surface waters than unmanaged areas. Although grazing areas are typically well vegetated, livestock tend to congregate near feeding and watering areas and create barren areas that are susceptible to erosion (Sutton 1990). Livestock that are not excluded from streams deposit manure and thus bacteria directly into waterways.

As shown previously in Table 1 and Figure 2, the Upper Shoal Creek watershed is dominated by hay and pasture, with a total of 69 square miles potentially grazed by livestock in the Upper Shoal Creek watershed. Aside from livestock present in permitted CAFOs, the exact type and number of livestock present in the upper Shoal Creek watershed is unknown. An estimate of the number of cattle in the watershed was calculated by using the available land cover data and county cattle population numbers provided in the United States (U.S.) Department of Agriculture's 2017 Census of Agriculture (NASS 2017). Using the total number of cattle in the Barry County, the county where the majority of the watershed is in, and the proportion of the area of pastureland in the watershed to the total area of pastureland in Barry County, it is estimated that there are 19,425 cattle in the Shoal Creek watershed (Table 3).[8]

Table 3. 2017 Cattle Population Estimates for Pasture Areas the Shoal Creek Watershed

County	Cattle No.	Pastureland (Sq. Mi.)	Pastureland in Watershed (Sq. Mi.)	Pastureland in Watershed/ Total County Pastureland	Watershed Cattle No.
Barry	96,537	344.40	65.17	0.19	18,267

[7] Section 640.760 RSMo setback distances are: 50 feet from a property boundary, 300 feet from any public drinking water lake, 300 feet from any public drinking water intake structure, 100 feet from any perennial and intermittent streams without vegetation abutting such streams, and 35 feet from any perennial and intermittent streams with vegetation abutting such streams.

[8] This analysis assumes all areas identified as grassland or pasture are being used for cattle grazing and that cattle are evenly distributed among those areas. Additionally, although some animals may be confined in some areas, for purposes of this estimation the entire cattle population was assumed to be grazing on pasture areas.

Other types of livestock such as horses and sheep may also be contributing bacteria loads in the Shoal Creek watershed. However, existing data is insufficient to provide an estimate of the number and distribution of these other livestock in the watershed.

4.2 Riparian Corridor Conditions

Riparian corridor conditions have a strong influence on instream water quality. Wooded riparian buffers are a vital functional component of stream ecosystems and are instrumental in the attenuation of pollutants in runoff. Land cover within 100 feet of streams in the Shoal Creek watershed is presented in Table 4. Hay and pastureland constitute around 27 percent of the riparian corridors of streams in the upper Shoal Creek watershed. These areas may be more susceptible to *E. coli* loading. Only one percent of the riparian corridors in the upper Shoal Creek watershed is forested.

Table 4. Land Cover in Riparian Corridors in the Upper Shoal Creek Watershed

Land Cover Type	Riparian Corridor Land Cover Type Area	
	Area Square Miles	Percent
Developed, High Intensity	0.000	0.00%
Developed, Medium Intensity	0.007	0.16%
Developed, Low Intensity	0.033	0.77%
Developed, Open Space	0.116	2.69%
Cultivated Crops	0.047	1.09%
Hay/Pasture	1.169	27.19%
Shrub/Herbaceous	2.860	66.53%
Forest	0.044	1.02%
Wetlands	0.006	0.15%
Open Water	0.017	0.40%
Totals	4.299	100.00%

5. Existing Loads and Needed Reductions

As mentioned previously, the whole body contact recreation category A designated use is impaired due to high *E. coli* bacteria concentrations in the Upper Shoal Creek and the whole body contact recreation category B designated use is impaired in Pogue and Joyce Creeks. The *E. coli* target load for Upper Shoal Creek, Pogue Creek, and Joyce Creek are represented by a load duration curves that quantify the loading capacity at all possible flows. The load duration curves are displayed on Figure 4, 5, and 6. The y-axes quantify the *E. coli* mass load in cfu per day at the flow conditions (percentage of time flow is equaled or exceeded) on the x-axes. Lower flows are equaled or exceeded more frequently than higher flows (i.e., greater than 90 percent of the time). Observed data are plotted on the load duration curve graphs to demonstrate the magnitude of load reductions that are needed to meet the target and attain water quality standards. Points above the curve exceed the loading capacity and points on or below the curve are in compliance with water quality standards. The load duration curves also help to identify and differentiate between storm-driven loading and the presence of

continuous loading. Storm-driven loading is expected under wet conditions when precipitation and runoff are high. Continuous loading is evident at low flows when point source discharges have greater influence on water quality.

Table 5, 6, and 7 summarizes the target load at selected flows and the load reductions needed to meet that target load. The load reductions were calculated based on the geometric mean of observed *E. coli* data recorded during each selected flow condition. As shown, *E. coli* concentrations exceed water quality criterion during all flow conditions for Upper Shoal Creek. Pogue and Joyce Creek lack data for *E. coli* concentrations during Moist Conditions and Dry Conditions. However, for all other flow conditions, *E. coli* concentrations exceed water quality criterion.

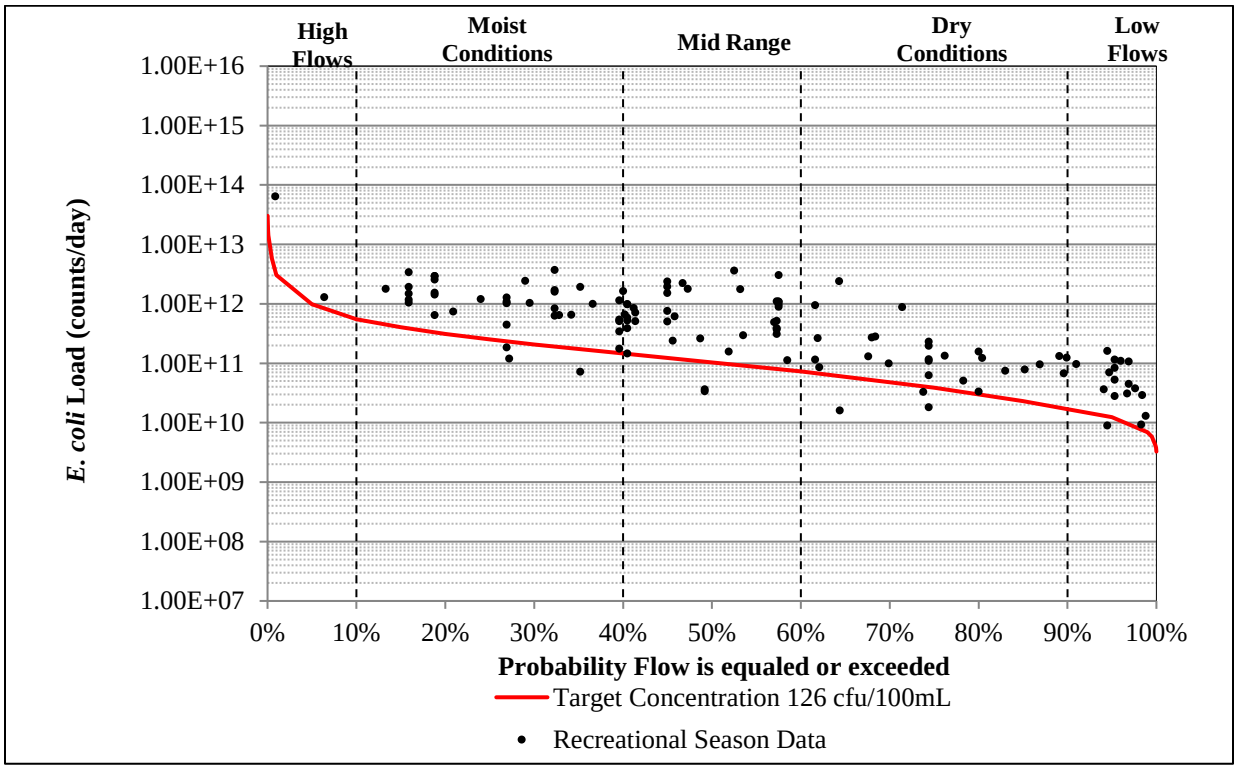

Figure 4. *E. coli* Load Duration Curve for Upper Shoal Creek

Table 5. Target *E. coli* Loads and Needed Reductions for Upper Shoal Creek

Time Flow is Exceeded	Flow Condition	Flow (cfs)	Target Load (cfu/day)	Existing Load (cfu/day)	Need Reduction (cfu/day)	Needed Reduction (%)	Existing Concentration (cfu/100mL)
0.95	Low flow	4.02	1.24E+10	4.46E+10	3.22E+10	72.20%	453
0.75	Dry conditions	12.59	3.88E+10	1.24E+11	8.52E+10	68.69%	402
0.5	Mid Range	33.35	1.03E+11	6.09E+11	5.06E+11	83.12%	747
0.25	Moist Conditions	81.39	2.51E+11	9.46E+11	6.95E+11	73.48%	475
0.05	High Flow	319.45	9.85E+11	9.13E+12	8.15E+12	89.22%	1,169

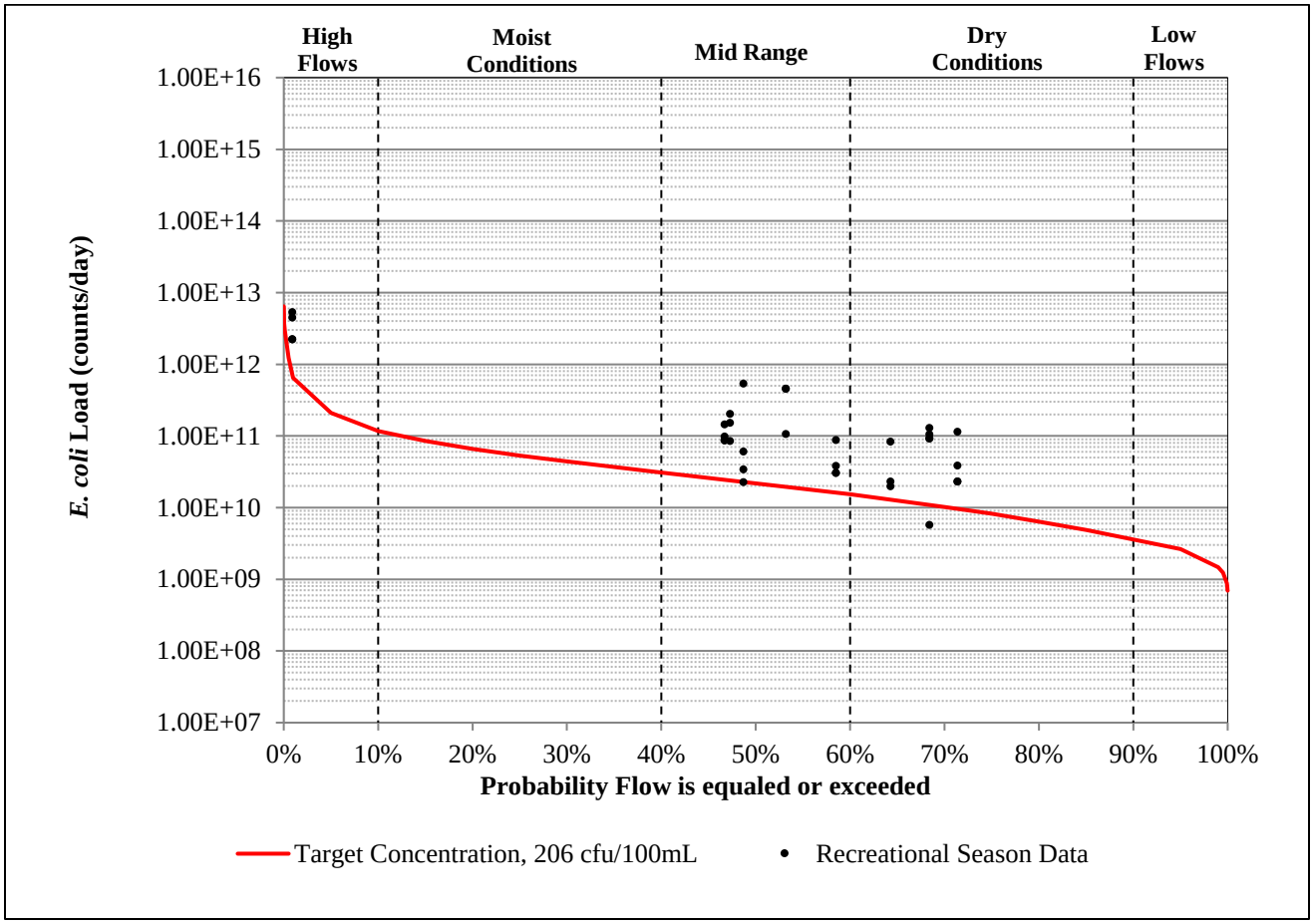

Figure 5. *E. coli* Load Duration Curve for Pogue Creek

Table 6. Target *E. coli* Loads and Needed Reductions for Pogue Creek

Flow Condition	Flow (cfs)	Target Load (cfu/day)	Existing Load (cfu/day)	Need Reduction (cfu/day)	Needed Reduction (%)	Existing Concentration (cfu/100mL)
Low flow	0.52	2.64E+09	No data	No data	No data	No data
Dry conditions	1.64	8.25E+09	4.46E+10	3.63E+10	81.49%	1,113
Mid Range	4.34	2.19E+10	9.63E+10	7.44E+10	77.30%	908
Moist Conditions	10.58	5.33E+10	No data	No data	No data	No data
High Flow	41.54	2.09E+11	3.31E+12	3.10E+12	93.67%	3,256

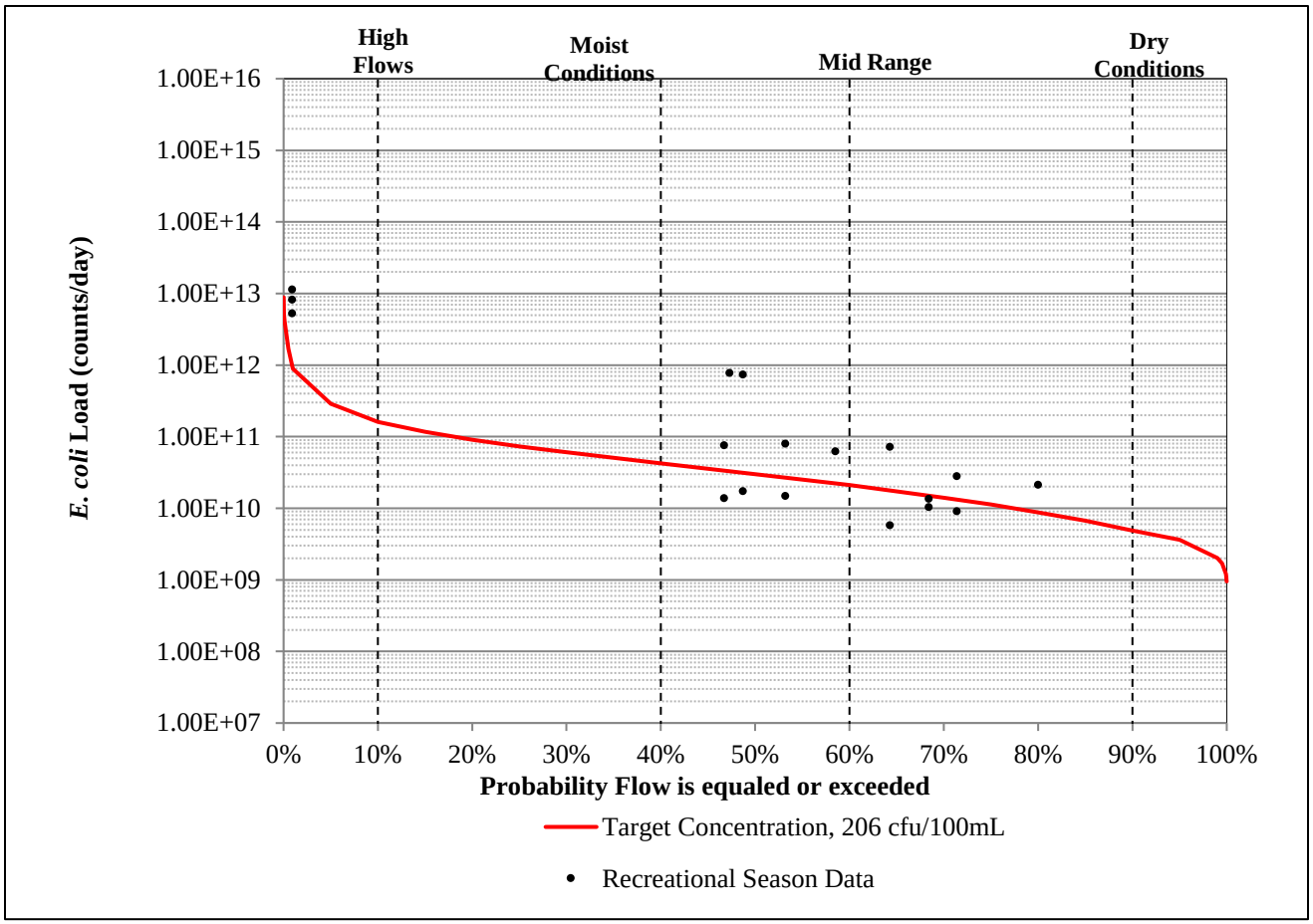

Figure 6. *E. coli* Load Duration Curve for Joyce Creek

Table 7. Target *E. coli* Loads and Needed Reductions Joyce Creek

Flow Condition	Flow (cfs)	Target Load (cfu/day)	Existing Load (cfu/day)	Need Reduction (cfu/day)	Needed Reduction (%)	Existing Concentration (cfu/100mL)
Low flow	0.72	3.62E+09	No data	No data	No data	No data
Dry conditions	2.25	1.13E+10	1.64E+10	5.13E+09	31.17%	299
Mid Range	5.95	3.00E+10	7.27E+10	4.27E+10	58.78%	500
Moist Conditions	14.52	7.32E+10	No data	No data	No data	No data
High Flow	56.98	2.87E+11	7.92E+12	7.63E+12	96.37%	5,678

6. Point Source Implementation

Federal regulations at 40 CFR 122.44(d)(1)(vii)(B) require permit conditions to be consistent with the assumptions and requirements of TMDL wasteload allocations. How these conditions are expressed can vary depending upon the pollutant and nature of the discharge. Although TMDLs are required to be written for daily time increments, permit effluent limits may be written in a form that derives from and complies with applicable water quality standards that use any time measure (40 CFR 122.44(d)(1)(vii)(A) and EPA 2006). The Department's permit writers have discretion for how TMDL wasteload allocations are expressed in a permit and for determining appropriate

implementation schedules. Permit writers should consult available permit writing handbooks and technical support documents to determine appropriate limits.[9] Although wasteload allocations are often specified for individual facilities, in some cases, it may be appropriate for pollutant loadings to be shifted between the individual facilities during permitting as long as the sum of the wasteload allocations remains unchanged and the loading capacity is not exceeded. In no case does a TMDL wasteload allocation allow for permit limits that exceed water quality standards. If water quality standard revisions result in criteria more stringent than an established TMDL wasteload allocation, then the more stringent criteria should be used in deriving the permit limits.[10] Information regarding the Department's permitting process is available online at dnr.mo.gov/water/business-industry-other-entities/permits-certification-engineering-fees/wastewater or by calling the Department's Operating Permit Section at 573-522-4502.

Table 6 lists the types of point sources in the Shoal Creek watershed that should be addressed in order to achieve the TMDL wasteload allocation targets. As of 2022 there are two domestic wastewater discharges present in these watersheds that are potential contributors of *E. coli* loading. Currently, both facilities disinfect the wastewater. In 2022, there were 27 concentrated animal feeding operations (CAFOs) in the Upper Shoal Creek watershed. As part of their permits, they are not allowed to discharge.

Table 6. Point Source *E.coli* Load Reduction Strategies

Type	Objective	Strategies
Domestic wastewater dischargers	Meet wasteload allocations assigned in Section 8 of TMDL report	• Appropriate *E. coli* permit limits • Disinfection • Consider no discharges option • Reduce occurrences of sanitary sewer overflows
Concentrated Animal Feeding Operations (CAFOs)	Meet wasteload allocations assigned in Section 8 of the TMDL report	• Maintain no discharge • Land apply waste according to permitted conditions • Nutrient management plans to manage manure application rates

[9] The Department maintains a Water Pollution Control Permit Manual to provide guidance to permit writing staff and is available online at dnr.mo.gov/water/business-industry-other-entities/permits-certification-engineering-fees/wastewater. Additionally the EPA maintains a National Pollutant Discharge Elimination System (NPDES) Permit Writers' Manual online at epa.gov/npdes/npdes-permit-writers-manual.

[10] Federal regulations at 40 CFR 131.21, also known as the "Alaska Rule," require water quality standards to be approved by the EPA before they can be used for Clean Water Act purposes (i.e., water quality-based effluent limitations or TMDLs).

Type	Objective	Strategies
Illicit straight pipe discharges	Unauthorized discharges should be eliminated from the watershed	• Report known discharges to local county health departments

7. Nonpoint Source Implementation

7.1 Focus Areas for Nonpoint Source Management

Areas that contribute the highest nonpoint source loading to Shoal Creek, should be prioritized for best management practices (BMPs). Typical focus areas are those where water bodies are adjacent to cropland and pastureland. The focus areas for nonpoint source management are displayed on Figure 4. Areas that may be highly responsive to BMPs are pastureland and cropland within 100 foot (ft) of a waterbody and where soils are categorized as hydrologic soil group D. Group D soils have the lowest water infiltration rate and highest runoff potential (NRCS 2011). Best management practices for nonpoint source load reductions will benefit water quality in Shoal Creek, Pogue Creek, and Joyce Creek when conducted in any area of their respective watersheds, but may provide greater efficiency in the identified focus areas. Landowners and watershed groups seeking Soil and Water Conservation and Clean Water Act Section 319 grant funds should prioritize activities based on local interest and potential for success.

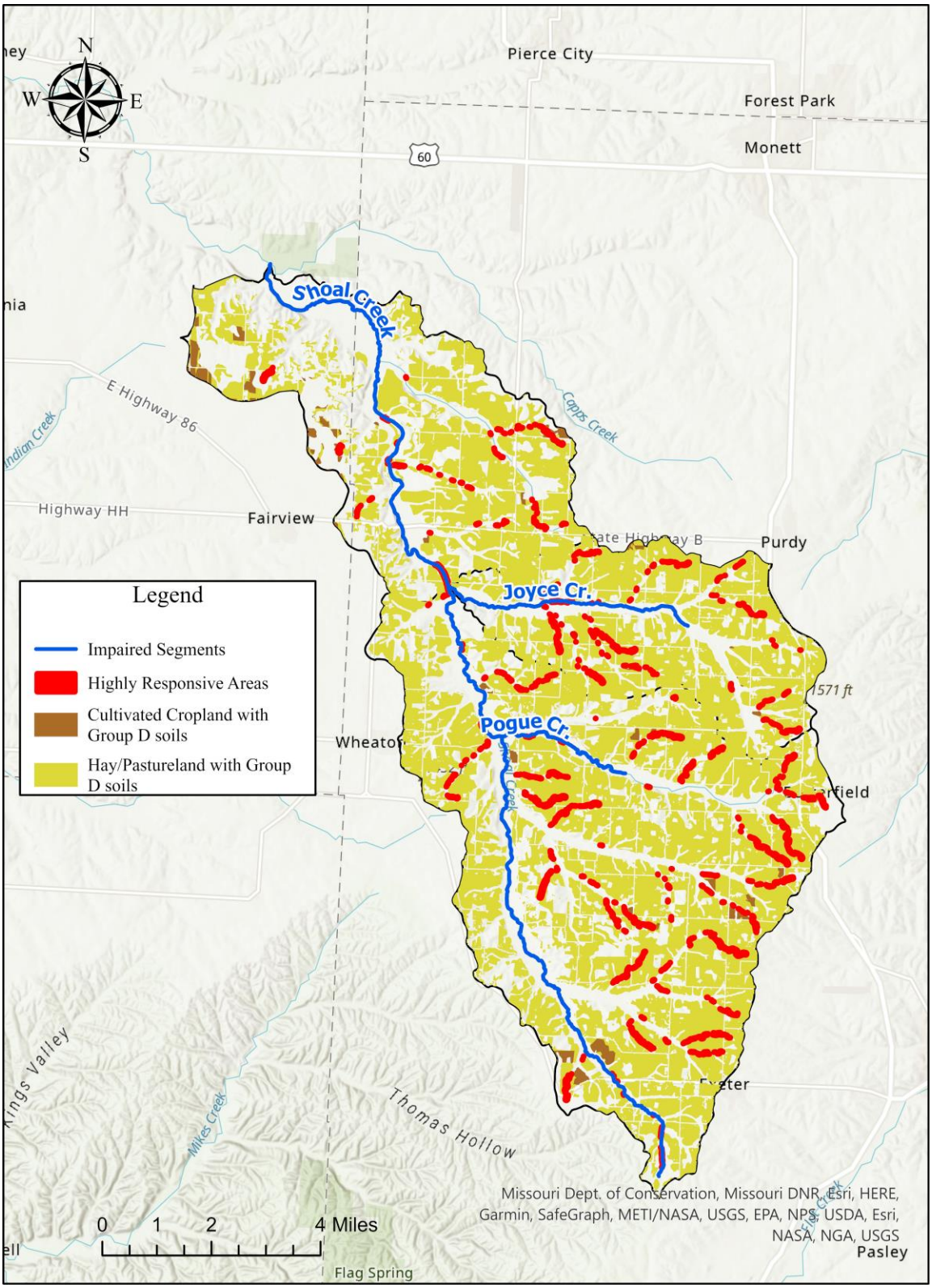

Figure 7. Focus Areas in the Shoal Creek Watershed[11]

7.2 Nonpoint Source Management Activities Previously Implemented

The Missouri Soil and Water Conservation Program provides cost-share programs to support the reduction of *E. coli* loading in agricultural watersheds. Cost-share projects implemented in the Shoal Creek watershed between 2016 and 2021 are summarized in Table 7. Many of the previously implemented BMPs are intended to reduce erosion. Erosion reduction practices may also reduce *E. coli* and nutrient loading.

Table 7. Nonpoint Source BMPs Implemented Between 2016 and March 2022

Practice Type	Number of Practices Funded	Total Treated Acres
Cover Crops	12	919.4
Grazing System Fence	5	336.9
Grazing System Water Development	2	151.2
Grazing System Water Distribution	6	416.1
Livestock Exclusion	5	118.6
Permanent Vegetative Cover Establishment	21	448.3
Permanent Vegetative Cover Improvement	7	190.6
Pest Management	6	343.8
Poultry Waste Management	4	0.0
Stream Protection	1	4.4
Total	69	2,929.3

7.3 Potential Nonpoint Source Management Measures and Expected Load Reductions

Nonpoint source management measures should focus primarily on reducing *E. coli* from hay and pasture lands because of the potential contributions from livestock. Suggested nonpoint source management measures are summarized in the following sections.

7.3.1 Riparian Buffers

Riparian corridor conditions have a strong influence on instream water quality. Wooded riparian buffers are a vital functional component of stream ecosystems and are instrumental in erosion reduction, as well as the detention, removal, and assimilation of pollutants in runoff. Therefore, a stream with good riparian cover is better able to mitigate the impacts of high pollutant loads than a stream with poor or no riparian cover. Shade provided by riparian corridors is also important because it helps to keep water cooler (cold water holds more oxygen) and reduces temperature variation that

stresses aquatic life especially during the critical low flows that typically occur in July and August. Approximately 28 percent of the riparian corridors in the upper Shoal Creek watershed are covered by either cropland or pastureland. Riparian corridors that lack woody vegetation should be prioritized for riparian restoration.

7.3.2 Streambank Stabilization

Streambank stabilization measures also reduce erosion. Such measures may include the installation of live stakes, coconut fiber rolls and mesh, coir rolls, bank terracing, large woody debris, and large boulders to support streambanks and reduce erosion. Integrating shrub and tree planting with other bank stabilization measures results in long-term stabilization as the vegetative roots expand and provide further soil stability. Many resources are available to guide streambank stabilization design for specific conditions. A good initial reference is the *Army Corps of Engineers Streambank and Shoreline Protection Manual* (https://www.lrc.usace.army.mil/Portals/36/docs/regulatory/pdf/StrmManual.pdf).

7.3.3 Livestock Exclusion

Livestock that have access to streams reduce streamside vegetation, increase barren areas, and contribute *E. coli* and nutrients directly to streams. In addition, compaction from animals contributes to poor quality aquatic habitat because the interstitial spaces in stream substrate are eliminated. Excluding livestock from streams is another way to improve water quality and aquatic habitat in the upper Shoal Creek watershed.

7.3.4 Nutrient Management

Nutrient management is one strategy for reducing *E. coli* and nutrient loading from agricultural lands to streams. The *Missouri Concentrated Animal Feeding Operation Nutrient Management Technical Standard* is available online at: https://dnr.mo.gov/document-search/missouri-concentrated-animal-feeding-operation-nutrient-management-technical-standard-march-4-2009. The technical standard describes soil and manure testing protocols, manure application criteria including required setback distances from streams, and monitoring requirements. Department staff are available to assist CAFO operators in the development of effective nutrient management plans.

The primary goal of nutrient management is to promote biomass productivity that provides profit for producers while minimizing negative environmental impacts. Over-application of nitrogen and phosphorus above the crop needs will cause these nutrients to accumulate in the soil and increase the potential for losses to the environment. Nutrient management planning minimizes the transport of *E. coli*, nitrogen, and phosphorus to surface and groundwater by optimizing manure application rates, timing, and placement, as well as accounting for all sources of nutrients.

Development of nutrient management plans may be eligible for cost-share from the Soil and Water Conservation Program. To be eligible for cost-share the Nutrient Management Plans should be developed in accordance with the Natural Resource Conservation Service Standards and Specifications for Nutrient Management (590). Landowner assistance is available through the Barry and Newton counties Soil and Water Conservation Districts.

In general, in order to be eligible for the cost-share for the Conservation Soil District, the following are required to begin nutrient management planning as stated by the Conservation Soil District:

- Soil samples, based on a 7-inch depth, shall be taken once every four years, as a minimum, to monitor the phosphorus, potassium, pH and organic matter levels and to adjust nutrient application rates as needed. The pH of the soil is important because it has a direct effect on nutrient availability. Iowa State University provides recommendations and soil testing procedures to develop a crop budget for determining crop nutrient needs. Nitrate testing using the late spring nitrate test and fall corn stalk test can be used to monitor the nitrogen management program. Soil pH levels shall be maintained near 6.5 for corn and soybeans and 6.9 for alfalfa.

- Manure analysis could be completed on an annual basis for percent of solids, total nitrogen, organic nitrogen, ammonia nitrogen, phosphorus pentoxide, potassium oxide and pH. A more realistic nutrient content can be obtained by using the averages of three or more analysis.

- Soil tests and realistic yield potentials will be used to determine the application rate of manure so as to supply most of the crop nutrient needs through the manure and legume credits. No additional commercial phosphate or potash will be applied on soils testing high or very high in phosphorus and potassium. On these fields additional commercial nitrogen will be applied as needed. This will optimize crop yield potential while minimizing nutrient runoff and nitrogen leaching.

- Sensitive areas: Commercial nutrients, manure and organic by-products shall not be applied to frozen, snow covered ground or saturated soil on slopes greater than five percent unless erosion is controlled. Manure and organic by-products shall not be applied within 200 ft. of a stream, lake, agricultural drainage well, or sinkhole unless injected or incorporated within 24 hours.

- Risk Analysis: The phosphorus index will be used to determine fields that are a high risk for phosphorus losses. Conservation and/or best management practices will be used to reduce the potential for phosphorus movement off site. Soil tests will be taken every four years to determine changes in phosphorus levels.

The plan should receive periodic review to determine if adjustments or modifications are needed. At a minimum the plan will be reviewed and revised with each soil test cycle.

7.3.5 Cover Crops

Planting cover crops rather than leaving cultivated cropland areas barren has both economic and environmental benefits. Legume cover crops can reduce fertilizer costs because of their symbiotic relationship with beneficial soil bacteria. Specific beneficial bacteria reside within nodules of the roots of legumes, such as vetch and clover, and convert nitrogen gas from the atmosphere into soil nitrogen that crops can use. This biological nitrogen fixation may reduce the amount of fertilizer that needs to be purchased and applied. Applying less fertilizer to the topsoil means reduced transport of nutrients to water bodies in the watershed. Cover crops also reduce erosion by holding soil in place and reducing top-soil crusting. The plant material left behind after cover-cropping increases water infiltration and reduces evaporation. This reduces the amount of nutrient or bacteria-laden runoff, and the amount of water needed for irrigation. Moisture retention by decaying plant material also helps soils be more resilient to periodic drought conditions.

A study conducted by Zhu et al. (1989) as cited in Sharpley and Smith (1991) found that planting common chickweed, Canada bluegrass, and downy brome on Missouri soybean fields decreased water runoff by an average 44 percent. The study found that nitrogen (as nitrate) loss was reduced by an average 75 percent and soluble phosphorus runoff was reduced by an average 37 percent. Sharpley and Smith (1991) found that planting ryegrass or wheat on peanut crops for 6 months of the year reduced soil loss by an average of 83 percent.

The Missouri Soil and Water Conservation Program provides cost-share opportunities up to 75 percent of the cost for planting cover crops, alternative crops, and vegetative buffer zones (field borders).

7.3.6 Prairie Strips

Implementing prairie strips in croplands can reduce soil erosion, and runoff contaminated with *E. coli* and nutrients. Prairie strips include edge-of-field filter strips and infield contour buffer strips. Infield contour buffer strips' primary purpose is to reduce erosion, while edge of the field filter strips' primary purpose is to filter excess nutrients and animal waste. A study conducted in Iowa found that converting 10 percent of crop field to prairie filter strips reduced average annual nitrate, total nitrogen, and total phosphorous concentrations by 35, 73, and 82 percent respectively (Zhou et al. 2014). The Department's Soil and Water

Conservation Program can provide cost-share of up to 75 percent of the cost of implementing prairie strips.

7.3.7 Field Borders

Field borders can provide a number of conservation benefits, such as reducing soil erosion from wind and water, protecting soil and water quality, and providing habitat for wildlife. These habitats, located at the edges of crop fields, can also serve to connect other buffer practices and habitats within the agricultural landscape. The U.S. Department of Agriculture's Farm Service Agency runs the Continuous Sign-up Conservation Reserve Program (CCRP) that provides farmers with rental payments on land set-aside for conservation buffers for a period of 10 to 15 years. Cost-share payments are also made available to help farmers with the financial burden of establishing the buffers.

8. Public Outreach

Public outreach is a key component of any watershed-based plan. Measures to reduce pollutant loading from nonpoint sources are implemented voluntarily and often through cooperation between citizen groups, landowners, government agencies, and funding entities. Support for watershed-based plans is generated through education and outreach activities designed to inform the public about water quality issues and what can be done to reduce pollutant loading in watersheds. The U.S. Environmental Protection Agency, U.S. Department of Agriculture, Natural Resources Conservation Service, Soil and Water Conservation Districts, Missouri Department of Natural Resources, Missouri Department of Conservation, University of Missouri Extension, and local governments produce educational materials and make them available on their websites. Staff within these agencies are available to assist with public education and provide technical support for watershed plan development. The following are some activities that may be implemented to develop support and participation for watershed stewardship:

1. Hold meetings and other outreach events to inform private landowners of the available technical support and financial incentives for implementing pollutant reduction strategies.

2. Attend livestock auctions and demonstrations in the local community, and hand-out literature explaining the available technical support and financial incentives for implementing pollutant reduction strategies.

3. Develop small-scale demonstrations of pollutant reduction strategies.

4. Implement a public awareness campaign regarding water quality with public service announcements.

5. Host local watershed festivals.

9. Measurable Milestones

Measurable milestones outline time frames for the incremental implementation of pollutant reduction strategies. Attainable milestones should be established based on available funding and stakeholder participation. For point sources, milestones may be integrated into permits as schedules of compliance to allow time to plan, fund, and construct facility upgrades or implement adaptive management. Watershed-based plans to reduce nonpoint source pollution should include milestones for public outreach, attaining funding, and the implementation of chosen best management practices. Plans that are developed with or to procure Section 319 subgrants must be renewed every five years to stay eligible for funding. It is good general practice to develop measurable watershed management milestones on 5-year timeframes. Periodic evaluations allow for an adaptive management approach that makes progress towards water quality goals, while using any new data and information to reduce uncertainty and adjust implementation activities.

10. Cost-Benefit

Cost-benefit analyses should be conducted during the watershed management planning process to determine the most efficient investments of time, effort, and supplies. Upgrades to point source facilities should consider both the immediate and necessary future capacity of the facility and should be designed based on the best available affordable technology. Costs associated with nutrient management plan implementation and cover crops are relatively minimal because many of the practices are already integrated into the farming system and substantial cost savings are achieved through reducing the need for manure application and chemical fertilizers. Streambank stabilization is the most expensive pollutant reduction strategy but can be prioritized to key areas to stabilize highly erosive streambanks for the benefit of water quality in all downstream waters.

11. Potential Government Assistance and Funding Sources

Reducing pollutant loading to achieve TMDLs often requires participation and technical support from government agencies. TMDLs are written to meet applicable water quality standards per federal regulations at 40 CFR 130.7(c)(1). Public service staff can often assist with outreach and education, provide technical guidance, and direct interested parties to potential funding sources. Some of the available agencies and organizations and their potential roles, including funding avenues, are listed in Table 8. The list is not exhaustive. The most commonly used sources of funding are low-interest loans or grants through the State Revolving Fund to implement point source goals, and Section 319 subgrants, and Soil and Water Conservation Program cost-share practices to implement nonpoint source goals.

Table 8. Agency Roles and Funding Options

Agency and Roles	Funding Options
US Department of Agriculture, Natural Resources Conservation Service https://www.nrcs.usda.gov/wps/portal/nrcs/site/mo/home/	

Agency and Roles	Funding Options
Financial assistance and incentives to implement voluntary best management practices	Environmental Quality Incentives Program (EQIP) Regional Conservation Partnership Program (RCPP) Conservation Stewardship Program (CSP) Agricultural Conservation Easement Program (ACEP)
US Department of Agriculture's Farm Service Agency (FSA) https://www.fsa.usda.gov/	
Administers a program called the Continuous Sign-up Conservation Reserve Program (CCRP) that provides farmers with rental payments on land set-aside for conservation buffers for a period of 10 to15 years. Cost-share payments are also made available to help farmers with the financial burden of establishing the buffers.	Continuous Sign-up Conservation Reserve Program (CCRP)
Missouri Department of Natural Resources https://dnr.mo.gov/	
Water Protection Program dnr.mo.gov/about-us/division-environmental-quality/water-protection-program Implements federal Clean Water Act regulations including: enforcing National Pollutant Discharge Elimination System (NPDES) regulations through point source facility operation permits, establishing Water Quality Standards, identifying impaired water bodies, and developing TMDLs.	Free volunteer water quality monitoring training and tools
Financial Assistance Center dnr.mo.gov/water/business-industry-other-entities/financial-opportunities/financial-assistance-center Provides technical guidance for publicly-owned treatment works and administers low-interest long-term loans to assist with technology and capacity upgrades. The Clean Water State Revolving Fund provides subsidized loans to municipalities, counties, public sewer districts, and political subdivisions for wastewater infrastructure projects. Loans may be paired with grant funds for qualifying communities. Eligible projects include new construction or improvement of existing facilities. Information on the Department's grant policy is available online at https://dnr.mo.gov/water/business-industry-other-entities/financial-opportunities/financial-assistance-center	Clean Water State Revolving Fund

Agency and Roles	Funding Options
Soil and Water Conservation Program dnr.mo.gov/land-geology/soil-water-conservation/ The Soil and Water Conservation Program (SWCP) provides financial incentives to landowners to implement practices that help prevent soil erosion and protect water quality. The program offers cost-share practices through its county conservation districts. Landowners may receive up to 75 percent reimbursement of the estimated cost of a practice through the program. The primary funding for cost-share practices from the Soil and Water Conservation Program comes from the one-tenth-of-one percent Parks, Soils, and Water Sales Tax.	SWCP cost-share
Section 319 Nonpoint Source Program dnr.mo.gov/water/what-were-doing/nonpoint-source-pollution-section-319/ Provides assistance with the development of watershed-based plans, and administers Section 319 subgrants for plan development and implementation.	Section 319 subgrants
Missouri Department of Conservation mdc.mo.gov/community-conservation/community-conservation-funding-opportunities/.	
Offers a number of grant and cost-share options including Community Conservation Grant and Land Conservation Partnership Grant. Provides outreach, education, and technical guidance for stream and watershed management issues. Maintains Missouri Conservation lands.	Community Conservation Grant and Land Conservation Partnership Grant Free volunteer water quality monitoring training and tools
Missouri Agricultural and Small Business Development Authority agriculture.mo.gov/abd/financial/awloanprg.php	
Offers an Animal Waste Treatment System Loan Program in cooperation with the Clean Water State Revolving Fund. Animal Waste Treatment Loans Program may finance eligible animal waste treatment systems for independent livestock and poultry producers with operations of less than 1,000 animals. Eligible costs include storage structures, land, dedicated equipment, flush systems, composters, and more.	Clean Water State Revolving Fund
University of Missouri Extension https://extension2.missouri.edu/	
Provides guidance for farm management including crop resilience, pond health, and livestock care.	Free information and assistance

Agency and Roles	Funding Options
County Soil and Water Conservation Districts https://mosoilandwater.land/	
Provides guidance and assistance with the development of nutrient management plans and procurement of funding from the state cost-share program.	Free information and assistance with grant applications
Online Databases of Additional Funding Sources	
▪ Wichita State University, Environmental Finance Center (EFC) Missouri Healthy Watershed Funding Search Tool https://www.wichita.edu/academics/fairmount_college_of_liberal_arts_and_sciences/hugowall/efc/news/meramec-funding-sources-landing-page.php ▪ Catalog of Federal Funding https://www.epa.gov/waterdata/catalog-federal-funding ▪ EPA Nonpoint Source Funding Opportunities http://water.epa.gov/polwaste/nps/funding.cfm ▪ Environmental Justice Grants https://www.epa.gov/environmentaljustice/environmental-justice-grants-and-resources ▪ Grants.gov http://www.grants.gov	

12. Conclusion

The ultimate goal of pollutant reduction strategies is to meet Missouri Water Quality Standards through the protection of whole-body contact recreation. Implementation strategies should follow an adaptive management approach that makes progress toward achieving water quality goals while using new data and information to reduce uncertainty and adjust implementation activities. Implementation efforts are expected to occur over a number of years, but within the schedules established in state operating permits and watershed-based plans. Success in achieving water quality standards will be determined by the Department through biennial assessments of water quality compliance as required by Sections 305(b) and 303(d) of the federal Clean Water Act.

The Department maintains administrative records for the Shoal Creek, Pogue Creek, and Joyce Creek TMDL. The records contain the TMDL document, this implementation strategies document, and other information on which the TMDL is based. This information is available upon request to the Department at dnr.mo.gov/open-records-sunshine-law-requests. Any request for information about TMDLs will be processed in accordance with Missouri's Sunshine Law (Chapter 610, RSMO) and the Department's administrative policies and procedures governing Sunshine Law requests.

13. References

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Appendix A
Nine Key Elements Critical to a Watershed-Based Plan

a. An identification of the causes and sources or groups of similar sources that will need to be controlled to achieve the load reductions estimated in this watershed-based plan (and to achieve any other watershed goals identified in the watershed-based plan, as discussed in item (b) immediately below. Sources that need to be controlled should be identified at the significant subcategory level with estimates of the extent to which they are present in the watershed (e.g., X number of dairy cattle feedlots needing upgrading, including a rough estimate of the number of cattle per facility; Y acres of row crops needing improved nutrient management or sediment control; or Z linear miles of eroded streambank needing remediation).
b. An estimate of the load reductions expected for the management measures described under paragraph (c) below (recognizing the natural variability and the difficulty in precisely predicting the performance of management measures over time). Estimates should be provided at the same level as in item (a) above (e.g., the total load reduction expected for dairy cattle feedlots; row crops; or eroded streambanks).
c. A description of the nonpoint source management measures that will need to be implemented to achieve the load reductions estimated under paragraph (b) above (as well as to achieve other watershed goals identified in this watershed-based plan), and an identification (using a map or a description) of the critical areas in which those measures will be needed to implement this plan.
d. An estimate of the amounts of technical and financial assistance needed, associated costs, and/or the sources and authorities that will be relied upon, to implement this plan. As sources of funding, states should consider the use of their Section 319 programs, State Revolving Funds, U.S. Department of Agriculture's Environmental Quality Incentives Program and Conservation Reserve Program, and other relevant federal, state, local and private funds that may be available to assist in implementing this plan.
e. An information/education component that will be used to enhance public understanding of the project and encourage their early and continued participation in selecting, designing, and implementing the nonpoint source management measures that will be implemented.
f. A schedule for implementing the nonpoint source management measures identified in this plan that is reasonably expeditious.
g. A description of interim, measurable milestones for determining whether nonpoint source management measures or other control actions are being implemented.
h. A set of criteria that can be used to determine whether loading reductions are being achieved over time and substantial progress is being made towards attaining water quality standards and, if not, the criteria for determining whether this watershed-based plan needs to be revised or, if a nonpoint source TMDL has been established, whether the nonpoint source TMDL needs to be revised.
i. A monitoring component to evaluate the effectiveness of the implementation efforts over time, measured against the criteria established under item (h) immediately above.

Appendix B.
Targeted Participants and Potential Roles in Implementation

The Department implements TMDL targets for point sources through the Missouri State Operating Permit program. For nonpoint sources, private landowners and citizen groups voluntarily implement water quality improvement projects and cost-share practices, which may be funded in part by grants or subgrants from the Department's Section 319 Nonpoint Source Implementation Program and the Soil and Water Conservation Program. Local governments, citizen groups, and individuals who have an interest in improving water quality in their communities may implement additional water quality improvement actions. Successfully meeting the goals of a TMDL often requires participation and cooperation from various parties within a watershed. Participant roles range from technical support to actual on-the-ground implementation of BMPs. Groups and agencies that may potentially be involved in the TMDL implementation process are identified below along with descriptions of their possible roles. This list is not exhaustive and not intended to compel participation from any organizations; nor is it meant to exclude those who are not listed, but may be interested in participating.

- Department of Natural Resources
    - Administers statutory authorities granted by Missouri clean water law.
    - Ensures permits issued in the watershed are consistent with the assumptions and requirements of TMDL wasteload allocations (the allowable point source load).
    - Provides compliance assistance to regulated entities.
    - Provides technical support to locally-led watershed groups.
    - Serves as a potential source of financial assistance for watershed plan development and BMP implementation through Sections 319(h) and 604(b) grants, or through Soil and Water Program cost-share practices.
    - Serves as a potential source of financial assistance for infrastructure improvements through low-interest State Revolving Fund loans.
    - Assesses attainment of water quality standards on a biennial basis for Clean Water Act Sections 303(d) and 305(b) reporting Implementation Strategies.
    - Provides education and training to volunteers through the Missouri Stream Team Program.
    - Provides technical assistance for market-based approaches to compliance such as water quality trading.
- County Soil and Water Conservation Districts
    - Provide financial incentives to agricultural producers to implement conservation practices that help prevent soil erosion and protect water quality.
    - Provide technical assistance with design, implementation, and maintenance of conservation practices.
- University of Missouri Extension
    - Provides technical assistance for addressing nonpoint source and watershed management issues.
    - Assists with organizing locally led watershed groups.

- Missouri Department of Conservation
    - Provides technical assistance with stream and watershed management issues.
    - Promotes maintenance and reestablishment of stable streambanks and functional riparian corridors.
- Missouri Department of Health and Senior Services
    - Provides technical assistance pertaining to onsite wastewater treatment systems (i.e., septic).
- County Health Departments
    - Provide technical assistance pertaining to onsite wastewater treatment systems.
- Locally led watershed groups
    - Develop and implement Section 319-funded nine key element watershed-based plans (See Appendix A).
    - Identify critical areas at a local level.
    - Implement BMPs to reduce nonpoint source pollutant loading.
    - Provide public education and outreach.
- Stream Team volunteers
    - Collect screening level water quality data (i.e., dissolved oxygen and biological monitoring) through the Volunteer Water Quality Monitoring program.
    - Provide stewardship, advocacy, and education.